REVIEWS.

ART. XX.—*Ether and Chloroform.*

1. *Death from Chloroform.* Lectures in Medical Times and Gazette, London, May and July, 1870. By BENJ. W. RICHARDSON, M.D.
2. *Remarks on Anæsthetics.* The Boston Medical and Surgical Journal, February 13, 1868. By HENRY J. BIGELOW, M.D., Prof. of Surgery in Harvard Medical School, and Surgeon to Massachusetts General Hospital.
3. *A Handbook of Therapeutics.* By SYDNEY RINGER, M.D. New York, 1870. Arts. "Chloroform" and "Ether."
4. *Anæsthetics.* By EDWARD R. SQUIBB, M.D., of Brooklyn, N. Y. New York, 1871. Pamph. pp. 30.
5. *Chloroform Deaths.* Twelve unpublished Cases. By W. W. DAWSON, M.D., Surgeon to Cincinnati Hospital. 1871. Pamph. pp. 34.
6. *Report of a Committee of the Boston Society for Medical Improvement, on the alleged Dangers which accompany the Inhalation of the Vapor of Sulphuric Ether.* Boston, 1861. Pamph. pp. 36.
7. *The Relative Dangers of Anæsthesia by Chloroform and Ether.* From Statistics of 209,893 Cases. By E. ANDREWS, M.D., Professor of the Principles and Practice of Surgery in Chicago Medical College. Chicago, Ill., 1870. Pamph. pp. 12.
8. *A System of Surgery.* Edited by T. HOLMES, Esq. Second edition. Art. "Anæsthetics." By JOSEPH LISTER, Esq.

THE consideration of the comparative safety of ether and chloroform has provoked an extended controversy. The surgeons of Boston and other parts of the United States, of Lyons, France, and of Naples, Italy, still adhere to the early anæsthetic. But in Edinburgh, London, Paris, and other quarters, the fortunate circumstances under which chloroform was heralded into the world, and the high anticipations which were excited by its peculiar anæsthetic qualities, combined to cast ether quickly into the shade. And there are obvious reasons why such should have been the case. The wonderful and unexpected fact of a safe induction of the anæsthetic state having been established, the scientific world was now prepared for and awaited new developments. Ether was the pioneer into a new region, and had announced that the way was safe. Around its history were clustered all the inconveniences and discomforts which usually attend the introduction of a new process, and which were due not to the agent, but to the inexperience of those who invoked its aid. There was much to do.

The question of the most appropriate method of administration, whether by an inhaler or from a sponge, had to be decided, and during this period of experiment many imperfect results were naturally to be expected. The ether used was often impure, and surgeons had to find this out and learn how to purify it.

The symptoms of the anæsthetic state were to be observed, especially those which portended danger. With all these disadvantages to contend against, no accident happened, if we except the case at Auxerre, in which ether was administered from an apparatus, "in a manner likely to produce asphyxia," and "insufficient means used for the restoration of the patient."[1] Referring to this case, Dr. Snow says "that death appeared to be occasioned by want of air, owing to an imperfect inhaler, and not to the effect of ether."

But chloroform found the way prepared, and men expectant and ready to greet it. The smallness of the quantity required to produce its effects, the ease with which the anæsthetic state was induced, and its pleasant odour, all conspired to cause exultation over the new substitute. Chloroform was established and its supremacy seemed assured. Scarcely had two months elapsed, however, when, after certain premonitions of danger, the public were startled from their fancied security by a "death from chloroform," undoubted and in no other way explicable. This occurred in January. A second death was recorded in February, another in March, and so on to this day has the ratio of mortality thus early assumed by chloroform not only held its own, but steadily increased, until the ominous record "death from chloroform" has become almost as familiar to medical journals as the titles they bear.

But, before proceeding further, the question of the mode of death presents itself. Since the first deaths from chloroform this question has been a fertile subject of discussion, and may now be considered far from settled.

All agree that this unfortunate result may occur in several ways. Without entering into a review of all the elaborate opinions which have been broached, we shall divide "death from chloroform" (considering first this agent) into two general classes: 1st, those occurring suddenly; and, 2d, those occurring gradually.

A large proportion of cases range themselves under the former class. The words[2] applied to a recent case, "the patient was yet only partially under the influence of the anæsthetic when death suddenly took place," will suggest themselves as the long familiar description associated with the record of chloroform deaths. Of the 109 cases[3] reported by the Committee on Chloroform to the Medico-Chirurgical Society, London—

Before full effect of chloroform	50 died.
During effect of chloroform	52 "
Not stated	7 "
	109

Out of 27 deaths which occurred within ten minutes, fifteen took place in less than two minutes.[4]

Referring to these cases, Sansom[5] says: "The first and most frequent is sudden death at the early stage of its [chloroform] influence."

Various explanations of these rapid deaths have been advanced. It is common, in order to remove the stigma from the agent employed, to say they are caused by fear or by an idiosyncrasy of the patient; but there is a much more obvious explanation, though neglected to a great extent by writers on these subjects—namely, the effect of a sudden impression upon the peripheral distribution of the vagus in the lungs, or, in other words, "shock."

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[1] Exposition et Histoire des principâles Découvertes scientifiques modernes, par Louis Figuier, Paris, 1851, t. ii. p. 282. Gaz. Médicale, 4 Mars, 1848, p. 170.

[2] Boston Med. and Surg. Journal, Feb. 17, 1870, quoted from Brit. Med. Journal.

[3] Sansom, p. 68, quoted from Am. Journ. of Med. Sciences, Jan. 1867, p. 165.

[4] Boston Rep., p. 10, quoted from Brit. Med. Journ. of Feb. 21, 1857.

[5] Am. Journ. Med. Sciences, Jan. 1867.

Dr. Henry J. Bigelow early recognized this fact. In 1848 he described[1] such deaths as due to "the sudden impression upon the system of a powerful inebriating agent."

This mode of death has, we believe, nowhere received more able and extended consideration than in a recent number of this Journal, where Brown-Séquard is quoted as follows: "It is by the reflex influence due to the sudden irritation of the branches of the par vagum in the lung, that chloroform has killed in the very rare cases in which the heart's action has been stopped before the respiration."

Dr. Benj. Richardson[2] has recently further elucidated the same idea. He quotes from a paper of Dr. Rutherford's,[3] "On the Influence of the Vagus upon the Vascular System." Dr. Rutherford writes:—

> "If any irritating vapour be brought before the nose of a rabbit, it instantly closes its nostrils and ceases to breathe, often for thirty or forty seconds. Within three seconds after the cessation of respiration the heart comes almost to a standstill, and continues to beat very slowly until respiration be re-established.
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> "The arrest of the heart is due to stimulation of the inferior branch of the vagus by the asphyxiated condition of the blood, for the slowing of the heart does not set in until death approach, if the vagi have been previously divided."

From this it appears that death has resulted from the action of the vapour upon the "nervous periphery of the breathing surfaces." The breathing ceases, and the vagus, stimulated by the asphyxiated blood, causes the heart also to stop beating.

Dr. Richardson thus arrives at the same result, namely, a sudden paralysis of the heart, by introducing as an intermediate step the asphyxiation of the blood. It also appears, according to Dr. R., that sudden death may be caused in another way. The arterioles of the lung, irritated by the vapour, suddenly contract, and the right heart is instantly paralyzed from the pressure of inflowing blood which can find no exit.

But whatever the explanation, the fact seems established that chloroform vapour is strongly irritant to the pulmonary surface, and to this may be attributed the occurrence of many of the sudden deaths.

Probably deaths not sudden, but produced by degrees, are caused either by asphyxia or syncope.

The state of asphyxia is determined either by a loss of motor power of respiration from the action of the anæsthetic upon the medulla oblongata, or from a congested state of the lungs, themselves due to disease in those organs.

Syncope is believed to result from the direct action of the anæsthetic upon the heart (or more explicitly the cardiac ganglia), or, as described under sudden deaths, may be the result of reflex action. Paralysis of the heart seems to be the most frequent cause of death.

Dr. Anstie says: "From the fact that in the immense majority of reported fatal cases, the first symptom of danger was confessedly the failure of the pulse and the blanching of the countenance, the conclusion appears strongly indicated that paralysis of the heart is the source of danger in surgical chloroform narcosis." M. Perrin and other eminent authorities hold the same belief.

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[1] Trans. Am. Med. Assoc., 1848, vol. i. p. 213.

[2] Med. Times and Gaz., May 28, 1870, p. 574.

[3] Journal of Anat. and Physiol., May, 1869.

But the heart is not always the weak point, and there seems to be a percentage of chloroform deaths in which the respiration is the first to fail. Opinion varies much as to the number. It is asserted that in many instances the only evidence that the heart has ceased to beat is the failure of the pulse at the wrist, and that this test is fallacious, because though the radial impulse may be absent, the heart may still be beating feebly.

In support of death by the lungs, we refer to the eminent authority of Mr. Lister.

Mr. Lister, after admitting the possibility of death from syncope, and referring to death from the shock of the operation, "the administration being insufficient to cause complete anæsthesia," then says, "the greater number of deaths still remain unaccounted for," . . . and "their explanation will, I believe, be found in an overdose of this potent narcotic from too long continued administration." The effect of an overdose is "strongly stertorous breathing," which "will become aggravated till it passes into complete obstruction to the entrance of air into the chest, though the respiratory movements of the thoracic walls still continue."

The patient is now "placed in imminent peril" from asphyxia, and Mr. Lister immediately puts in practice a process which he has for many years strongly insisted upon, viz., to seize the tip of the tongue with a pair of artery-forceps and draw it firmly forward, when "the respiration at once proceeds with perfect freedom, the incipient lividity of the face is dispelled, and all is well."

We are now prepared for the general statement that "the very prevalent opinion that the pulse is the most important symptom in the administration of chloroform, is certainly a most serious mistake. As a general rule, the safety of the patient will be most promoted by disregarding it altogether, so that the attention may be devoted almost exclusively to the breathing."

These directions Mr. Lister considers all-sufficient, and so obvious that both extensive experience and methods of administration other than on the simple folded cloth are unnecessary. (Mr. Lister thinks that the quantity of chloroform vapour given off from the under surface of the cloth is "below Dr. Snow's limit of perfect security," 4 to 5 p. c.) The danger of chloroform "is so small that it need not enter seriously into our calculations," and just as railway accidents are occasioned by culpable mismanagement, so death from chloroform is almost invariably due to faulty administration."

It would certainly be a great point gained if the vital defect of chloroformization could be thus definitely settled and the responsibility shifted to administrators. But it must be remembered that the frequent deaths associated with this very method of administration have been the incentive to the invention of numerous complicated apparatuses to regulate the quantity of vapour inspired, and that the explanation of death by an overdose does not account for a very large proportion of deaths which it is well known are sudden, before the full anæsthetic effect and before the operation has commenced, and when but a trifling amount of chloroform has yet been given. We should not like to agree with Mr. Lister, that death from chloroform is chargeable to the administrator and due to "culpable mismanagement," for it is known that five deaths[1] under the method of the folded cloth have occurred at the Edinburgh Infirmary. And just before his death the introducer of chloroform himself had occasion to lament the occurrence, at the same institution, of a most typical case of death from chloroform administered by his own hands, and from the folded cloth or lint.[1]

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[1] British Medical Journal, June 17, 1871.

However, we agree with Mr. Lister that his method is the best; for Clover's inhaler, the most nearly perfect of all the apparatuses, has had a large share of victims, and where all methods kill, the simplest is undoubtedly the best. And, on the whole, if chloroform is to be used at all, nothing can be more admirable than the clear and simple directions given by Mr. Lister for its employment. His instructions reduce the process of chloroformization to its simplest terms, but necessarily, as we believe, leave unprovided for the unpreventable and unmanageable toxic influence of the drug.

Deaths from apnœa, ordinarily referred to paralysis of the muscles of respiration, have also received another ingenious and plausible explanation,[2] viz., direct local anæsthesia of the lungs, owing to which these organs become insensible to the presence of carbonic acid, and thus fail to transmit to the respiratory centres the necessary stimulus to respiration.

A sudden death from the effects of ether has never been recorded.

A gradual death can be produced in two ways: 1st, by cutting off the proper supply of atmospheric air with inhalers and undiluted vapour; or 2d, by prolonging the inhalation beyond the stage of deep narcotism, until the medulla oblongata is paralyzed and respiration abolished, followed shortly by cessation of the heart's action.

In both cases the fatal result is due to asphyxia. During the anæsthetic process the whole nervous system is not affected at once, but different parts successively succumb. The nervous centres which control involuntary and semi-voluntary action are the last to yield, but it is evident that if the inhalation be sufficiently prolonged, these too at last become involved, and life ceases. The heart is then the *ultimum moriens*. The question of liability to death of this nature from ether will be discussed later.

Both the public and the profession early recognized the dangers of chloroformization. Among the first to take a decided stand against it were the surgeons of Boston.

Dr. John C. Warren wrote at length against the use of chloroform. Dr. Geo. Hayward, in a pamphlet[3] published in 1850, says, after adducing other objections to chloroform, "but there is a stronger ground on which we can rest our opposition to the use of chloroform, that is its danger to life; it cannot be denied that fatal effects have followed its inhalation when administered by the most judicious hands."

Dr. Henry J. Bigelow, one of the very earliest advocates of ether, thus concisely expresses his opinion in tabular form :—

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[1] British Medical Journal, July 2, 1870.

[2] "On one of the Causes of Death from Chloroform." By Andrew H. Smith, M.D., of New York. N. Y. Med. Journ., July, 1871.

[3] Comparative Value of the Different Anæsthetic Agents, by Dr. Geo. Hayward, Boston, 1856, p. 9.

	Conveniences.	Inconveniences.	Dangers.
Ether..................	....	Pervading smell	Little.
Chloroform	More portable, and less of it answers the purpose.	Blisters skin unless the face is thoroughly oiled.	It kills people.

Surgeons abroad, especially in France, were not behind in their expressions of apprehension.

M. Malgaigne, in his report on chloroform to the Academy of Medicine of Paris, arrived at the following conclusion: "Chloroform possesses a toxic action peculiar to itself, which has been taken advantage of in medicine, by arresting it at the period of insensibility; which action, however, may, by being too much prolonged, cause death."

Subsequent experience has confirmed the opinion of Malgaigne, and it has become painfully evident that it is not always possible to arrest this inherent poisonous action with sufficient accuracy to avoid causing death.

The question was seriously proposed[1] in 1859, before the "*Société de Chirurgie*," of Paris, by M. Hervez de Chégoin, referring to chloroform, "whether its use had not better be actually suspended, until some method of using it with constant security shall be discovered, or, if it is to remain of so uncertain safety, even renounced altogether."

In 1857, Ricord, before the Academy of Medicine, spoke of the use of chloroform as "an accident which complicated an operation."

Mr. Erichsen, of London, says[2] of the stage of insensibility induced by chloroform "when thus fully anæsthetized, the patient is, undoubtedly, on the very verge of death."

In 1850, Petrequin, a distinguished surgeon of Lyons, writes,[3] "from the day when I saw chloroform in the hands of the most skilful practitioners cause successive and numerous lamented victims, I became convinced that I ought to reject far from me a poison of a character so subtle, that frequently what should have been an ordinary sleep became, with the rapidity of lightning, the sleep of death; and for which science knew no antidote."

There has been nothing in the subsequent history of chloroform inhalation to contradict the conviction of danger which had thus early become associated with its use.

On the contrary, its dangers are by many freely admitted, and the comparative safety of ether allowed. A wide-spread feeling of uneasiness, having its origin in the constantly recurring and seemingly unavoidable fatal results which, year by year, certainly and surely congregate around chloroform, is now agitating the British mind. Dr. Benjamin W. Richardson, than whom there seems to be no one more familiar with the special study of anæsthetics, says "there is, under the most favourable aspect of chloroform, a given mortality, just as there is a mortality from accidents and acute diseases like fevers."

Dr. Kidd states, "This school [London] would have it that there is always a certain number of deaths, and must be. *This is the pervading*

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[1] Séance du 9 Mai, 1859.

[2] Erichsen's Surgery, p. 44.

[3] Gazette Hebdomadaire de Méd. et de Chirurg., 12 Janvier, 1866, p. 21.

impression now in London." And, again, he laments "this confusion of ideas that exists in the English mind as to the readiness with which chloroform acts and kills." He continues, "as a rule of nearly 400 accidents from chloroform, the patients were in rude health."

Physicians and the newspapers have hitherto retained the almost exclusive right of discussing the "deaths from chloroform," while courts of justice have deferred to the opinion of the physician. That the "medico-legal bearings of chloroform" may assume a new shape is suggested by a recent coroner's verdict of "death from the effects of chloroform administered without proper degree of care," "in fact, a verdict of manslaughter," says the *Medical Times and Gazette*, from which this is quoted. It does not appear from the account given, that this administration was conducted in an unusual manner, and, in defending the administrator, the *Times* says further, that death from chloroform is "*an accident which is by no means very uncommon, which has happened to the most experienced surgeons and chloroformists, and which no skill and no precautionary measures could prevent.*"

What more complete and unqualified admission of the dangers of chloroform than this could there be, coming as it does from the very advocates of chloroform themselves?

But to ascertain the exact number of fatal results, or what is more desirable still, the number of deaths relative to the administrations, has always been found a difficult task. One undoubted death from chloroform which would not occur from ether under similar circumstances, should be enough to decide the question of their relative merits. But many have occurred, well proven, of immediate death, at the very beginning of chloroform inhalation. And there is not on record a death from ether of this description. And this fact alone would be sufficient to ground the conclusion that ether was the safer anæsthetic, and therefore always to be preferred to chloroform. It is well known, moreover, that many deaths go unrecorded, owing to the reluctance of the operator to have this stigma attached to his reputation. At a recent meeting of the British Medical Association, Dr. Hughes Bennett remarked that "there were many deaths from chloroform that were never published," and after relating a sad case of the kind, he closed his remarks by saying that "this was only one of many similar cases that had occurred, but had never been published." Dr. Andrews says, "Physicians resident in Paris inform me that only about half of the known deaths from anæsthesia (only chloroform is used there) appear in print in that city, while in England and in this country probably not one-fifth part are ever published."

Dr. Richardson believes that cases occur constantly which are not recorded.

We present such statistics relating to the number of "deaths from chloroform," as we have been able to secure, premising that they are very imperfect.

In the *British Medical Journal* of July 2d, 1870, is a "Table of deaths from chloroform in the United Kingdom during the last eighteen months." From this it appears that in 1869 eleven deaths occurred, and up to May in 1870, six, nearly all of them in hospitals, and thus necessarily reported. This number of cases (11) nearly corresponds with the annual average as ascertained from the tables of the Registrar-General of England.

It will be noticed in the table given below, that a very small number of cases were registered for the five years ending 1856, viz., 13. Referring to this fact, the Registrar-General says that "perhaps the cause of death in the former period may not have been so well recorded as in later years." No record was kept for the years between 1856 and 1863.

TABLE ABRIDGED.—*England. Deaths Registered from Chloroform in the Years* 1852–56, 1863–68.

Years.	Total number of deaths.
5 years. 1852–56.	13
1863	10
1864	9
1865	12
1866	7
1867	7
1868	14
Total	70

Annual average from 1863 to 1868, five years, 9.5.

Apply this average to the twenty-three years which have elapsed since the introduction of chloroform, and we obtain a total of 218.5 deaths from chloroform in Great Britain alone.

Dr. Snow, in 1858, by a most vigorous system of exclusion of doubtful cases, had recorded fifty deaths. In 1865, Dr. Sanson had collected the records of fifty more, making 106 to that date. The committee on chloroform in their report to the Royal Medical and Chirurgical Society give 109. Kidd, as quoted, gives 400. Perrin and Sabarth each chronicle about 200. But here, in our first attempts to obtain the ratio of mortality from chloroform, the data fail. The estimates of the actual number are made by chloroformists, and are restricted to their narrowest possible limits. Let any one familiar with the medical literature of journals and magazines consider if he cannot recall more than nine deaths per annum, and he will convince himself that "the half has not been told."

During the year 1869, for which the *British Medical Journal* gives eleven deaths occurring in Great Britain alone, the *Medical News and Library*, published in Philadelphia, recorded twenty-five.

In a late number of the *Practitioner*, edited by Dr. Anstie, of London, Dr. Augustus Waller, a distinguished physiologist, lately deceased, writes as follows: "The administration of chloroform in the most skilful hands, and while surrounded by all the appliances of hospital practice, is still undeniably attended with a certain amount of danger." . . . "So much is this the case, that, as Dr. Prevost pointed out to me, there were three fatal cases from chloroform within a few days' interval, in the different hospitals of Paris, where it was administered for the purpose of reducing dislocation of the head of the humerus."

If throughout the rest of the world the whole number of chloroform deaths has equalled those occurring in Great Britain, as estimated from the annual average of the Registrar-General, namely 218, the estimate of Kidd of 400, will be none too small. As late as 1869, an editorial of the *British Medical Journal* says: "*We have had deaths from chloroform almost every week.*" Dr. Dawson writes: "Since October last, the date of my unfortunate case, I have collected, with but little trouble, the history of twelve hitherto unpublished cases, most of them having occurred in this vicinity." In fact, we believe that few even dream of the magnitude of the number that chloroform has killed. However, the low estimates of chloroformists, given above, show that the number of killed is greater than by any other drug of the Materia Medica.

There have been a number of estimates of the ratio of mortality. Of these, two bear upon their faces evidences of inaccuracy, but are nevertheless very generally quoted. In 1859, Dr. Chapman estimated that chloroform had been administered throughout the world 1,200,000 times, and collecting 74 deaths, he calculated that the ratio of death was as 1 to 16,000 administrations. Dr. Sabarth estimated that the number of administrations for fourteen years, had been 3,000,000, and collecting 119 cases of death, he estimated that the mortality was as 1 to 26,000.

The sources of error in these estimates—first, the impossibility of approximating to the whole number of administrations, and second, the difficulty of ascertaining the actual number of deaths—render the calculations too rude to be relied upon.

Two other calculations, of Dr. E. Andrews,[1] of Chicago, and of Dr. Benjamin W. Richardson,[2] of London, give estimates differing from the two already quoted, as much in accuracy of method as in the proportion of deaths to administrations. Dr. Andrews, from the data of 117,078 known administrations, and 43 recorded deaths among this number, computes the deaths to be as 1 to 2723 administrations. Most singularly, Dr. Richardson's estimate led him to adopt nearly the same ratio. He found "that in the twenty-one years from 1848 to 1869 inclusive, in thirteen hospitals there were 35,162 administrations of chloroform, with a proportion of eleven deaths." He "believes this to be the largest reliable series of cases of administration as yet collected," and "knows it to be just." "Doubtful cases of death from the agent there were none, and in every case a qualified and competent practitioner was the administrator." Dr. R. continues: "I compute favourably from the facts that the rate of mortality is as 1 in 3500 administrations of chloroform (I really think it is greater, and that one death in 2000 to 2500 administrations would be nearer the truth)."

Dr. Squibb, in his excellent pamphlet, makes the only estimate we have seen of the ratio of deaths to administrations of chloroform, applicable to this country. With every facility for accuracy as to the amount of chloroform manufactured annually, he states it to be 80,000 pounds. This and the annual number of deaths reported make up the data of an estimate which he frankly states "is *simple speculation or rough estimate.*" Supposing one-third of 80,000 pounds, or say 26,000 pounds, is used for anæsthetic purposes by inhalation, and that one and a half fluidounce is used and wasted for each administration, "this would give 26,000 × 8 = 208,000, or say 200,000 administrations," a very extravagantly safe estimate for the whole country during 1870. Dr. Squibb finds 17 deaths recorded for this year. Thus the ratio of deaths is as 1 to 11,764 administrations. But since "some estimate that not more than one-half of chloroform deaths are ever publicly known," Dr. S. doubles the recorded cases, and adopts for safety the ratio of 1 to 5882, though he "believes the first estimate to be nearest the truth."

We would suggest that since a large proportion of anæsthesias throughout the United States are induced by ether, and many in dental practice by nitrous oxide, that 100,000 annual administrations of chloroform is large enough. This number, with the number of deaths quoted above, would give a ratio of 1 to 3000, about the same ratio as that of Dr. Andrews and Dr. Richardson.

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[1] The Relative Dangers of Anæsthesia, p. 7.

[2] London Medical Times and Gazette, July, 1870.

Deaths associated with the administration of ether have undoubtedly occurred; we say "associated with the administration of ether" advisedly, for the opinion is now very widely held that a death resulting from any noxious quality inherent in this agent is not recorded. No one doubts, we believe, that death can be produced by administering the vapour of ether undiluted with atmospheric air, and by prolonging the administration until the patient is dead.[1] But plainly death is due not to the agent, but to the method of exhibiting it. Numerous drugs of the Materia Medica can be given either in therapeutic or toxic doses. So with ether. But between the two agents there is this difference. *With ether, the possibility of taking life rests with the administrator; he can kill with it, but there exists no inherent necessity of doing so; nor is it probable that signs of danger can escape his notice. With chloroform, having decided to use it, the possibility of causing death is beyond human skill or foresight.* Dr. Snow, after careful attention to ether administration, writes: "I hold it almost impossible that a death from ether can occur in the hands of a medical man who is applying it with ordinary intelligence and attention."

In Boston, where ether was first introduced and used exclusively now for over twenty years, no well-authenticated case of death has ever occurred or been heard of in the vicinity from it. Throughout the United States, anæsthesias, except for extraction of teeth, are about equally divided between ether and chloroform, but deaths from anæsthetics are almost invariably recorded in connection with chloroform administrations.

In attempting to determine the number of deaths connected with ether, we are very materially aided by the labours of the "Boston Committee," whose report embraces the results of most patient research and accurate knowledge. This committee was able to obtain the records of only forty-one cases of death thought to be attributable to ether. But this formidable number faded rapidly when subjected to the light of investigation. Every one of these cases was rejected by the committee. It was found that 6 of them had occurred in from 11 to 16 days after the operation, 9 in from 3 to 6 days, others in from 3 to 50 hours, leaving but 8 which occurred during the operation or inhalation, and 8 in which the time which elapsed was not stated. Of these 16 cases, the committee think "that the connection between the result and the inhalation is either problematical or else manifestly absurd and unfounded, except in four instances where it was due to asphyxia brought about by wholly avoidable causes."

The conclusions of the committee have, we believe, never been rebutted, and there is good reason to believe that every year's experience with anæsthetic agents is strengthening their position. The importance of these conclusions must be our excuse for quoting them in part.

1. "The ultimate effects of all anæsthetics show that they are depressing agents. No anæsthetic should, therefore, be used carelessly, nor can it be administered without risk by an incompetent person."
2. "It is now widely conceded, both in this country and Europe, that sulphuric ether is safer than any other anæsthetic, and this conviction is gradually gaining ground."
3. "Proper precautions being taken, sulphuric ether will produce entire insensibility in all cases, and no anæsthetic requires so few precautions in its use."

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[1] See case in Boston Med. and Surg. Journ., Dec. 8, 1870.

> 4. "There is no recorded case of death, known to the committee, attributed to sulphuric ether, which cannot be explained on some other ground equally plausible, or in which, if it were possible to repeat the experiment, insensibility could not have been produced and death avoided. This cannot be said of chloroform."

Dr. Andrews, whose rate of mortality by chloroform has already been quoted, collected also 92,815 administrations of ether, with four deaths, or 1 in 23,000. But a further examination of these instances of death brings to light facts and evidence not quoted in Dr. A.'s pamphlet.

Of the four cases cited, two are from the well-known Lyons series, and have been fully discussed by the medical society of that city, whose decision, given elsewhere, does not bear out Dr. A.'s opinion that these were veritable deaths from ether. One case was the excision of the superior maxilla, and Dr. Andrews certainly could not have been aware that in this instance the question of death from hemorrhage was seriously entertained, and that finally the society voted that the ether took but a secondary share in producing death ("*l'ether n'a joué qu'un rôle sécondaire*"). Of the other Lyons case, Dr. A. omits to mention that it was a serious and long operation, and that the patient so far revived as to *take* "restoratives." And further, M. Gayet, the reporter, explains at length that the ether was not the only factor in producing a fatal result.

The third of Dr. Andrews' cases occurred at the New York Hospital, and was also an excision of the superior maxilla. It is well known that in performing this operation the greatest precaution is required to prevent death from suffocation produced by the unavoidable entrance of blood into the trachea, and so great and real is this danger, that in the practice of many surgeons the first step in the operation is tracheotomy. The same danger of death by suffocation applies to the first Lyons case already alluded to. Finally, as to Dr. Andrews' fourth case, he simply says: "One case of death is reported to me verbally by the officers of St. Thomas's Hospital, London. I could not learn the particulars." We think that this case should not be accepted until the details of the operation were furnished. Cases of this kind could, of course, be multiplied. For instance, but recently, a late student of University College, London, informs us, that during his attendance at St. Thomas's Hospital, he, in common with the medical class, *saw* three deaths from chloroform occur on the operating tables of that institution.

Dr. Andrews' pamphlet is a valuable addition to the literature of ether and chloroform statistically considered, and is evidently the fruit of much labour. We must, however, wait for better proven cases before abandoning the position taken by the committee of the "Boston Society," that there has not yet been recorded a case of death fairly attributable to ether. And we see no reason to reject the spirit of the Lyons Society's conclusions. However, according to Dr. Andrews' estimate, chloroform is eight and a half times as dangerous as ether.

The surgeons of Lyons, France, like most other continental surgeons, received with enthusiasm the new anæsthetic, chloroform. But a series of fatalities soon occurring under its use, by formal vote of their Academy of Medicine they again adopted ether.

And the result has been most satisfactory, if we may judge by the words of M. Petrequin, one of the ablest advocates of ether abroad. He writes:—

> "During the fourteen years which have elapsed since chloroform was abandoned at Lyons and ether came into general use, we have not been called upon

to deplore the death of a single victim in the hospital practice where, in less than two years, five or six deaths from chloroform have occurred.

"After many sittings devoted to a profound discussion, the Society of Medicine of Lyons voted *unanimously* the following conclusions:"[1]

1. "Ether employed to produce surgical anæsthesia is less dangerous than chloroform."
2. "Anæsthesia is produced as certainly and as efficiently by ether as by chloroform."
3. "If ether offers inconveniences which chloroform does not present to the same degree, these inconveniences are of little importance, and do not counterbalance the inherent danger of the latter agent."
4. "Consequently ether should be used in preference to chloroform."

In 1868 the Medical Society of Lyons, influenced by the occurrence of a death during etherization, again appointed a committee to examine the relative dangers of ether and chloroform, and this committee came to the same conclusions as before. We quote the 4th, 5th, and 6th:—

4. "Of the seven cases (since 1847), five relate to patients severely attacked (profondement atteints), and the two others were patients in special conditions —pregnancy in the one and hystero-neuropathy in the other."
5. "In none of these cases was death so sudden as it often is from chloroform."
6. "Ether may, indeed, cause death, but it is far less dangerous than chloroform."[2]

From the facts stated, and from further considerations, which the necessary limits of a review compel us to curtail, we come to these conclusions:—

Historical.—1. Ether preceded chloroform by over a year, and answered every purpose of an anæsthetic.

Physiological Action.—2. From the study of the direct action of ether and chloroform upon the tissues, no differences are established.

From the study of the phenomena indicative of the action of ether and chloroform upon the tissues, several differences of importance in favour ether are established.

(*a.*) The excitement alleged to accompany the use of ether is prove to be exaggerated, and to be really but little more than accompanie the use of chloroform.

(*b.*) The heart is conclusively shown to be depressed in its action by chloroform—stimulated or at least not depressed by ether. From which is deduced the surgical point, that in a state of collapse ether is the best agent to use.

(*c.*) Pupil, no differences elicited.

(*d.*) Vomiting, in favour of ether.

(*e.*) Death, from the opinions of scientific men and societies, and particularly from a comparison of the physiological action of both agents, we feel justified in saying that—

  (α.) Death from chloroform is possible, is probable, and, more, in a definite percentage of cases, is necessary and unavoidable.

  (β.) Death from ether is possible, is not probable, and need never occur.

This disposes of the question of safety as pertaining to ether and chloroform; and here, at the very point where the discovery of anæsthesia hung in abeyance for so many years—a point so vital, that until its demands were satisfied no discovery could be made—chloroform fails.

In those quarters of the world where ether is in use, the settled conviction of its safety, entertained by all concerned, is noticeable. Any one, as it happens, etherizes. The operation goes on with scarcely a thought of the patient, for every one feels that, with the most ordinary attention, signs of danger are noticed long before they become urgent. If necessary, the patient is often kept for hours under the influence of the anæsthetic, and it seldom becomes necessary to appeal to any means of resuscitation. Lastly, the patient, after a long operation, "is put to bed with a flushed face and great surface circulation.[1]

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[1] Gaz. Hebdomadaire, 12 Janvier, 1866, p. 25 and 24.

[2] Boston Med. and Surg. Journ., Feb. 6, 1868.

If we can judge by chloroform literature, the scene is quite a different one when that agent is employed. Administrators are instructed[2] to be always on the lookout for danger.

"*A point which must be kept constantly in mind by chloroform administrators is, that no case is safe. It is just when danger is least thought of, that it comes.*" And it is a fact, that a constant dread of a fatal result does exist.

Conscious of this death-dealing property of chloroform, European surgeons have surrounded its use with every possible safeguard.

In the large hospitals, trained assistants only administer the drug, so that a professional chloroformist is a necessary part of the hospital staff. All the means of resuscitation are kept close at hand. And a most extended literature on the subject of recovering the patient has sprung up.

It is indeed of the highest credit to European, especially British chloroformists, that by their extreme precautions and solicitude for the safety of their patients, they have drawn almost from out the grave many who would otherwise have fallen victims to this deadly agent.

The necessity of the intervention of art to save the patient has become of common occurrence, and the resuscitated to-day outnumber the killed.[3]

But the latter class already is numbered by hundreds. Unerring statistics, at their lowest estimate, proclaim that the monument to the slain has risen higher and higher each year, and must continue to rise. Human skill and ingenuity have already been taxed to their utmost to make a poison safe. The voices of men highest in their profession are being continually raised to proclaim its danger. And yet, in the face of all this, we are told that the preference must be given to chloroform.

> "So far as we have yet gone, it seems very probable that chloroform will hold its place with the British profession as being the safest anæsthetic which combines the recommendations of durable effect, rapidity of influence, suitability to all ages and states of health, freedom from after-consequences, and ease of administration."[4]

And in this brief sentence, which is but one of many quotations which might be cited to the same effect, we are told why chloroform must hold its place. We decline to accept such statements as final. We have shown, as we believe, that ether is safer, and we shall, we trust, make it evident that this agent combines with its use as fully as does chloroform every essential and necessary qualification of an anæsthetic. Let us pass briefly in review some of the disadvantages most frequently charged to ether. These are: Time necessary to produce anæsthesia; durability or persistency of anæsthetic effect; quantity of the agent required; certainty of action; suitability to all ages and states of health; agreeableness to patient.

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[1] Boston Med. and Surg. Journ., Sept. 29, 1870, p. 207.

[2] British Med. Journ, editorial, Nov. 27, 1869.

[3] Out of 3058 administrations of chloroform by Dr. Anstie, alarming symptoms occurred in 21, or about 1 in 145. On Stimulants and Narcotics, p. 377.

[4] British Medical Journal, November 27, 1869.

Time.—Chloroform anæsthetizes rapidly, but this very rapidity is an element of danger, for it is acknowledged that the sudden and overwhelming impression upon the nervous system has been the most frequent cause of chloroform death. Evidently, then, chloroform anæsthesia must be induced gradually and slowly, a point which is recognized by the invention and use of inhalers to prevent the undue and early action of the vapour. With Clover's inhaler, four minutes at least is required to produce anæsthesia. Ether anæsthetizes slowly, and it is essential to present its vapour to the system in a state sufficiently concentrated. Etherization must be hastened to be successful; chloroformization must be retarded to be safe. Dr. Snow states that the average time of etherization for adults is from four to five minutes, and all administrators agree in estimating the time at from four to six minutes. Thus ether in this respect differs but little, if at all, from the necessarily delayed use of its potent rival.

Dr. Squibb says: "When properly managed, ether, if not quite as prompt as chloroform, is as prompt as any anæsthetic can be to be safe." And Dr. Anstie writes,[1] "Chloroform cannot be given safely with greater rapidity than ether."

Durability or Persistency of Effect.—The insensibility of ether anæsthesia is more permanent than that of chloroform. But the contrary has been so often asserted, that it is well to dwell a moment upon this point. Ether is far more soluble in the serum of the blood, and is retained in the blood and tissues longer than chloroform. Consequently its action is of longer continuance. Dr. Snow especially noted this; he says:[3] "On account of this longer duration of the effects of ether, it is better adapted for certain operations on the face, as removal of tumours of the jaws, the operation of harelip, and making a new nose." And bearing upon the same point, Dr. Anstie says:[3] "Chloroform, which speedily anæsthetizes, speedily leaves the organism free; ether, which is slower in its operation, more slowly ceases to act."

Quantity.—The quantity of ether required to produce a single anæsthesia is large when compared with chloroform. Four fluidounces will often suffice for an ordinary operation, but frequently as much as eight or ten are required. By the use of an inhaler, such as proposed by Dr. Squibb or Dr. Lente, the quantity required becomes very much smaller. When a sponge is employed, as is generally the custom, several ounces are turned freely upon it, and it is then closely applied to the face; and if lividity, or a certain rigidity of the muscles sometimes noticed, supervene, a few breaths of fresh air will immediately banish these symptoms, and anæsthesia will then follow with more than the usual rapidity.

But the ratio between the amounts of ether and chloroform required to procure insensibility is not preserved if it becomes necessary to prolong the operation, for the blood once saturated with the former, retains it longer than it does the latter, and a small additional amount serves to maintain insensibility. But the question of amount is really of minor importance in civil practice. In the campaign, the consideration of bulk becomes of more importance.

No discussion can be needed upon the question of certainty, for the assertions that ether is less certain in its action than chloroform, must arise from total unfamiliarity with its use, or from intentional misrepresentation.

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[1] Stimulants and Narcotics, p. 227.
[2] "On Anæsthetics," p. 361.
Stimulants and Narcotics, p. 469.

And as to suitability to all ages, and applicability to all states of health, the same rules apply to both agents. Freedom from after-consequences refers particularly to vomiting, which, however, follows chloroform full as often as it does ether, and sometimes with more disastrous effect. Undoubtedly, the odour of ether is not so agreeable as that of chloroform. But considered not in comparison with chloroform, but by itself, this odour is not unpleasant to very many. And admitting this objection to ether in its full force, it is at best trivial, and not an objection so much urged by patients as by administrators.

As bearing directly and with great force upon the points under discussion, we cannot forbear quoting from the words of Dr. Henry J. Bigelow:[1]—

> "The great objection to ether is its odour: to chloroform, its danger: although few people hesitate to encounter as great danger to life in a long journey by sea or land. To such the danger of chloroform might not be an objection to its use, were it not that ether is perfectly safe and offers a ready alternative. When chloroform kills, the only warning it gives is the death of the patient, who dies suddenly by shock, and in spite of precautions. With ether no such accident is possible; its effects may be readily and perfectly graduated, its danger foreseen and easily averted. . . . There is no difference whatever in the nausea or vomiting produced by the one or the other, nor in the subsequent aversion to either anæsthetic of patients once thus made sick, nor in the character nor degree of other unpleasant symptoms, danger excepted; and the sooner these facts are wholly recognized, the better for the absolute safety of the patient, as preference will then be given to ether in spite of its odour. Had ether a pleasant odour, it would be as an anæsthetic far superior to chloroform."

Indeed, with the records of *death* from chloroform constantly in view, it scarcely seemed necessary to examine the preceding questions of *convenience*, were it not that these are the very points upon which chloroformists are compelled to base their preference. But, viewing the question of comparative merit from this stand-point alone, we have shown that the advantages of chloroform are more apparent than real—advantages for the physician, and not for the patient; that since the potent character of chloroform requires it to be given slowly, and the difficulty of getting ether sufficiently concentrated necessitates its rapid administration, the time consumed in inducing anæsthesia is practically about the same; the quantity used is of little moment; the pleasant odour of chloroform may count for what it is worth; and finally, as to durability of effect, this advantage should not again be claimed for chloroform, for it is plain that in this respect ether is decidedly superior.

But admitting for a moment that chloroform presents advantages over ether, of rapidity, small quantity, and pleasant odour, we cannot consider that such recommendations offset the certainty of blotting out the life of a certain percentage of human beings. And especially do such recommendations fall short of offsetting the dangers of chloroform, when considered in view of the fact that in ether we have at command a perfectly safe and innocuous agent from which death would be a rare and unexpected event.

Whatever be the explanation of it, it is a fact that throughout chloroform literature ether is seldom represented in a fair light. We quote from a work[1] on materia medica, only lately "officially recommended to the medical students of the University of Dublin:"—

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[1] Boston Medical and Surgical Journal, Feb. 13, 1868.

"It was found that ether inhalation was very *uncertain* in its effects, producing in many persons *violent* excitement, spasmodic action of the muscles, *delirium*, and in some instances *death* even following its employment."

This is the final instruction given in regard to ether. Nothing more contrary to facts than are these statements can be conceived. And yet professional opinion, in Great Britain more particularly, sustains statements of this nature, whether through ignorance or national prejudice it would be impossible to say.

At no time in the history of chloroform has more inquietude possessed the minds both of medical men and the laity than at present, and yet there appears no disposition (with a few exceptions) to recognize the full merit of ether. Deaths from chloroform are charged to idiosyncrasy of the patient, to emotion, "fatty heart," anything but the agent itself. New methods of inhalation, and precautions to be exercised, are constantly advanced, and numberless new anæsthetic agents are experimented with. Ether meanwhile has been apparently ignored. Such is the general statement, but in many quarters a reaction has occurred, and its use is being quietly but surely established. A large portion of the human race at some time seek relief of the physician from suffering, and he has no moral right to consult his own convenience and force upon his patients an additional risk. This he does by employing chloroform. The comparison of Mr. Erichsen and Mr. Lister of the respective use of ether and chloroform to the choice between a slow and safe or quicker and more perilous railway train, and the conclusion that the world generally accepts the risk of the latter, does not meet the case, for the traveller assumes his own risk when he undertakes the journey. If, however, he is in pain and suffering, he must get relief, and *another* party now decides the amount of risk for him, viz., the physician. Has he then, for purposes of his own, a right to put his patient upon the most dangerous train? The physician assumes the responsibility of danger, and not the patient, who is incapable of an opinion as to which is the safer course. Physicians, and surgeons particularly, as some sudden stroke of chloroform, for the first time in their own experience, takes from under their hands a life, which they were aiming to save, feel this responsibility.

Now for a time every one awaits a new anæsthetic, but, in spite of the highest anticipations, it has not yet been found.

The feeling of insecurity and danger must soon find some termination, and the inevitable result must be, we conceive, a large diminution of the popular use of chloroform, and a far more universal resort to ether.

W. J. M.

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[1] Neligan's Medicines. By Rawdon Macnamara, Prof. Materia Medica, &c. &c., Dublin, Ireland.